Physico-Chemical Evaluation of Groundwater in Kuje, Federal Capital Territory, Abuja, Nigeria

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ABSTRACT: This study was done to determine the quality of water from hand-dug wells in Kuje, Federal Capital Territory Abuja Nigeria. The study area lies between latitudes 08^0 53’ 24’’N and 08^0 53’ 47’’N and longitude 07^0 14’ 24’’E and 07^0 14’ 35’’E. Water from twenty wells were randomly sampled. The physical properties investigated are pH, temperature, total dissolved solid (TDS) and electrical conductivity. The chemical analysis involved determination of the concentration of anions (SO_4^{2-}, HCO_3^-, Fl^-, CO_3^-, Cl^-, NO_3) and cations (Ca^{2+}, Mg^+, Na^+,K^+, Zn^+, Fe^{2+}, Cu^{2+}. A piper diagram based on the relative percentages of the ions was plotted for classification according to hydrogeochemical facies of each water sample based on their dominant ions. The Piper diagram indicated Ca^{2+} and HCO_3^- as the dominant ions and therefore it is Ca−HCO_3 water type. The physical properties of the water were found to be good based on World Health Organization (WHO) guidelines and National Drinking Water Quality Standard (NDWQS) and therefore water in the study area is safe for human consumption.

KEYWORDS: groundwater, hydrochemical facies, anion, cation, piper diagram

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I. INTRODUCTION

Increase in demand for water resources globally occurs essentially due to population growth and modern developments. Thus the welfare of every society is tied to the sustainable exploitation of water resources (Bear, 2000). Groundwater accounts for about 98% of the world’s fresh water and it is fairly well distributed throughout the world (Buchanan, 1983). Groundwater continues to serve as a reliable source of water supply in most rural and urban communities in Nigeria. Groundwater is a renewable resource, its availability and use of which are influenced by many factors such as the lithology of the area, climatic patterns and water quality (Anornu *et al.*, 2009). However, human activities and seepage of hazardous materials into groundwater have affected its quality (Olasehinde, 1998; Ajibade *et al.*, 1987). In Nigeria groundwater is an important resource both in the rural and urban areas and is susceptible to quality degradation from anthropogenic activities.

The attendant increase in water pollution and implication to the environment has been studied by several researchers. The studies have highlighted the need for thorough assessment of the quality of water used for human consumption, agricultural and industrial purposes.

Amadi, Olasehinde, and Okosun (2010) used Water Quality Index (WQI) method to evaluate the quality of Otamiri and Oramiriukwa Rivers in Owerri, Nigeria. About 180 samples of water were collected for physicochemical and bacteriological analysis using APHA standard methods of analysis. The overall WQI for all the samples was said to be 174.49. Eludoyin, Ofoezie and Ogunkoya (2004) determined the effect of Oja-titun market effluent on the chemical quality of receiving Opa Reservoir in Ile-Ife, Nigeria. Water samples were collected in sixteen sites, four along each of the market drainage channels, market stream, tributary system and the Opa River and reservoir. Ige, Bale and Olasehinde (2008) evaluated the physio-chemical characteristic of water sources in Imeko, South-western, Nigeria.

The peak level of each variable-biochemical oxygen demand, temperature, total alkalinity, Na+ K+, Ca^{2+} Mg^{2+}, $P0^{2-}$, $S0_4^+$, $Cl^{,}$ NO^{-3}, Pb and Zn that occurred at the areas decreased significantly downstream, except pH, conductivity, total dissolved oxygen which increased. There were high values in the early day and dry season and low values in the rainy and early rainy season. Comparison of the reservoir water with international standard for drinking water supply showed that the quality of the reservoir water was very low.

A total of twenty two (22) water samples within and around Imeko town were collected for analysis. The water samples comprise of eighteen (18) hand dug wells, two (2) boreholes and two (2) spring sources. The hydrochemical characteristics of the area revealed that the cationic concentrations is in the order of Mg > Ca > (Na+) for the wells, boreholes and surface water sources while the anionic concentration is in the order of HCo3 > SO4 > Cl. Statistical and graphical approaches of interpretation indicated two different types of water present in the study area which are Mg, Ca^-, K^+, Na^- HCO3 and the Ca - K+ NaSO4. The Mg-HCO3 type shows the predominant marine sources of pollution while the Ca – So4 type water is from industrial sources.

Usman and Dosumu (2006) analysed cadmium in fertilizers and ground water samples in Dass Local Government Area of Bauchi State, Nigeria. Five different market samples of

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fertilizers used by farmers in Bauchi State were purchased and analysed for their cadmium (Cd) content using Atomic Absorption Spectrophotometer (AAS). The groundwater was collected from different sites where rice is under intensive cultivation and heavy fertilizer application for between 5 to 30 years period. Long term application of fertilizers on rice farm was found to be responsible for high concentration of Cd in the groundwater. The studies have highlighted the need for thorough assessment of the quality of water used for human consumption, agricultural and industrial purposes.

Berhanu (1996) described the origin of high bicarbonate and fluoride concentrations in water of the main Ethiopian Rift Valley, East African Rift and from deep wells reaching depths of up to 2500 m below the surface in the Aluto-Langano Geothermal field. The thermal water in the Main Ethiopian Rift Valley are characterized by high Na, bicarbonate and fluoride concentrations and near-neutral to alkaline pH while sodium, bicarbonate and fluoride are positively correlated in the water. The principal reason for the bicarbonate in the area is the high rate of carbondioxide out gassing. This combined with acid volcanics, geothermal heating, low Ca and low salinity is also one of the causes of high fluoride in this part of the active volcanic zone of the East African rift. Evaporative concentration is responsible for the high salinity, alkalinity and fluoride in the closed-basin lakes of the region.

The purpose of this research was to undertake a physico-chemical analysis of water from twenty hand-dug shallow wells in Kuje area of the Federal Capital Territory (FCT), Abuja, Nigeria and to compare the quality with the water quality standard of the World Health Organization (WHO).

II. Geological Settings

The study area, Kuje, is in the south-eastern part of Federal Capital Territory, Abuja. It lies between latitudes 080 53’ 24’’ N and 080 53’ 47’’ N and longitudes 070 14’ 24’’ E and 070 14’ 35’’ E. It is located at about 13.2 km from Abuja municipality. The study area is predominantly underlain by the Precambrian basement complex rocks. The basement complex of Nigeria has been classified in several ways. But the most recent and widely accepted is the classification of Oyawoye (1964) which is basically classified into three main geological units namely; migmatite-gneiss complex, older granite suite sometimes called the intrusive suite and the schist belt.

The polycyclic migmatite gneiss complex consist of high grade rocks mainly migmatite and gneiss of largely uncertain origin with relics of amphibolites. The gneiss migmatite complex is believed to have been initially established in the Archean time and affected by several orogenic events of which the most important is the Liberian event which is 2,750 ± 50 myrs. The older granite suites consist of granite, granodiorite which truncates or crosscut both the gneiss migmatite complex and the schist belts. They range from granitoid to underformed granite.

The subordinate member includes pegmatite vein, quartz and aplite. The rocks found in the older granite suites are all of pan African age that is 600 ± 10 myrs. The schist belt consists mainly of pelitic and semi politic metasediments interbedded with metamorphosed mafic to ultramafic volcanics. They occur as a relatively narrow North-South trending belt within the gneiss migmatite complex, and are believed to be vestiges of supracrustal sediments which were folded into pre-existing bedrock known to be at least of paleoproterozic age. Examples of the schist belts include: Jebba quartz, Efon granite formation, the metamorphic grade of the rocks ranges from medium to low grade.

However, the local lithological units in the study area are migmatite gneiss, granite, and schistose gneiss. The migmatite gneiss is the most wide spread rock unit, while the granite occurs in several locations. They are porphyritic and of medium-coarse-grained texture. Granites mostly occur as intrusive, low-lying outcrops around the gneiss. They are severely jointed and fairly intruded by quartz veins (Oyawoye, 1964). The area is drained by seasonal streams. The topography is characterized by flat and elevated terrains. Plate 1 shows the granite of the study area while migmatite-gneiss is shown in Plate 2.

Plate 1: Granite with joints in the study area.

Plate 2: *Migmatite gnesis* in the study area.

III. Materials and Methods

Samples of well water at the study area shown in Figure 1 were collected and properly labelled at the location of collection. Twenty groundwater samples were collected. The

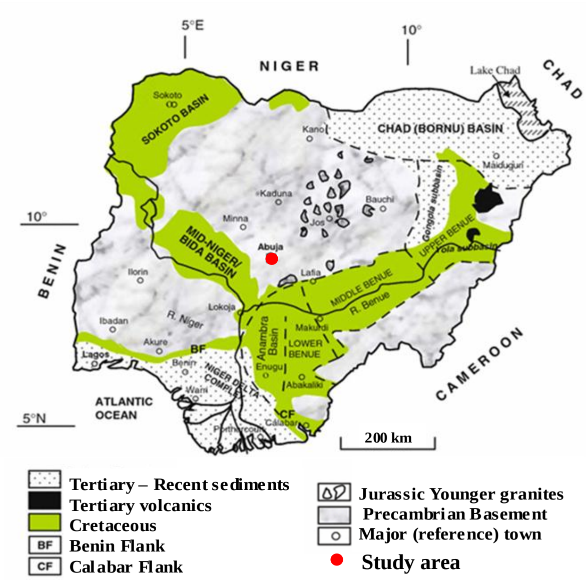

Figure 1: Geological map of Nigeria showing the study area.

water samples were collected using 2 litre containers which were initially washed with detergents and samples were immediately covered with a scale cap to avoid reaction with atmospheric oxygen.

The static water level in the wells and the total depth of wells were measured with a weighted graduated tape. The elevation, longitude and latitude of the well location were observed using Global Positioning System (GPS). The water temperature, pH, total dissolved solid (TDS), conductivity and salinity were measured in-situ using pH meter, thermometer and salinity meter. The samples were analysed in the laboratory within 48 hours of collection using an atomic absorption spectrophotometry (AAS) whose schematic diagram is shown in Figure 2. The cations analysed are Ca^{+}, Mg^{+}, Na^{+}, K^{+}, Cu^{2+}, Fe^{2+}, Zn^{2+}, and the anions are NO_3,SO_4^{2-}, Cl^{-}, HCO^{-}_3, Fl^{-}, CO_3^{-}.

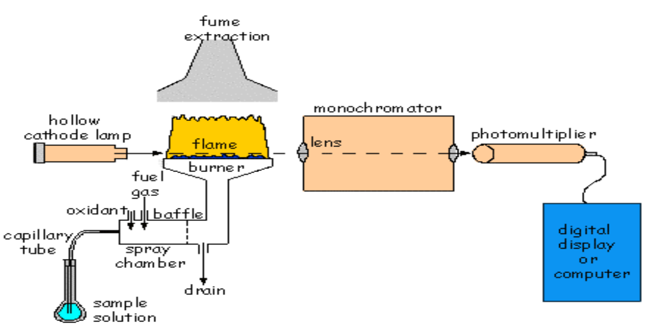

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Figure 2: Schematic diagram of atomic absorption spectrophotometry.

IV. RESULTS AND DISCUSSION

The pH of water samples ranged from 6.47 to 6.94, as presented in Table 1. These values fall within the acceptable Nigerian standards (2007) and World Health Organization standards (1996) for potable water. The total dissolved solids (TDS) of the water ranged from 420 mg/l to 1258 mg/l, indicating a high concentration of total dissolved solids when compared with World Health Organization Standards (1996).The electrical conductivity ranged from 686 μS/cm to 1935 μS/cm and may have been affected by the high TDS as shown in Table1. The temperature of the groundwater ranged from 27.5^{o}C to 29.9^{o}C.

Table 1: Results of Physical Parameters.

Loc.	Long. (N)	Lat. (E)	pH	Cond (μS/cm)	TDS (mg/l)	Temp (°C)	Sal.
1.	08^{0}52’7”	07^{0}13’7”	6.4	1935	1258	27.5	1.5
2.	08^{0}52’7”	07^{0}13’7”	6.4	892	580	27.5	1.5
3.	08^{0}52’6”	07^{0}13’6”	6.6	1025	669	28.8	2.2
4.	08^{0}52’6”	07^{0}13’7”	6.6	714	470	28.9	2.1
5.	08^{0}52’6”	07^{0}13’7”	6.5	1241	761	28.7	2.2
6.	08^{0}52’6”	07^{0}13’6”	6.5	998	561	28.7	2.1
7.	08^{0}52’61	07^{0}13’6”	6.5	686	420	28.6	2.9
8.	08^{0}52’6”	07^{0}13’6”	6.9	1271	835	29.0	1.9
9.	08^{0}52’7”	07^{0}13’6”	6.9	1761	1144	29.4	2.2
10.	08^{0}52’7”	07^{0}13’6”	6.9	1556	1013	29.7	2.1
11.	08^{0}52’7”	07^{0}13’7”	6.9	987	650	29.4	1.6
12.	08^{0}52’7”	07^{0}13’6”	6.9	1183	770	28.6	1.7
13.	08^{0}52’8”	07^{0}13’9”	6.9	1599	1043	29.5	1.3
14.	08^{0}52’8”	07^{0}13’9”	6.9	946	620	28.8	2.1
15.	08^{0}52’7”	07^{0}13’9”	6.8	883	581	28.8	1.5
16.	08^{0}52’7”	07^{0}13’9”	6.9	1429	930	28.3	1.6
17.	08^{0}52’8”	07^{0}13’10”	6.9	1305	860	28.6	1.8
18.	08^{0}52’7”	07^{0}14’01”	6.9	1088	710	29.4	2.5
19.	08^{0}52’7”	07^{0}14’00”	6.9	794	480	29.2	1.8
20.	08^{0}52’7”	07^{0}14’03”	6.9	1466	965	29.9	1.3

On the basis of physical properties, groundwater in Kuje area is fit for human consumption. The high TDS can be reduced using simple filters. The concentrations of Mg^{2+}, Na^{+}, Cu^{2+}, Ca^{2+}, Zn^{2+}, Fe^{2+}, NO_3^{-}, SO_4^{2-}, and Cl^{-} are within the permissible limits of the WHO (1996) standards for potable water as shown in Table 2. The piper plot for the chemical constituents of the water reveals Ca^{2+} and HCO_3^{-} as the dominant ions and therefore it is Ca−HCO3 water type as shown in Figure 3.

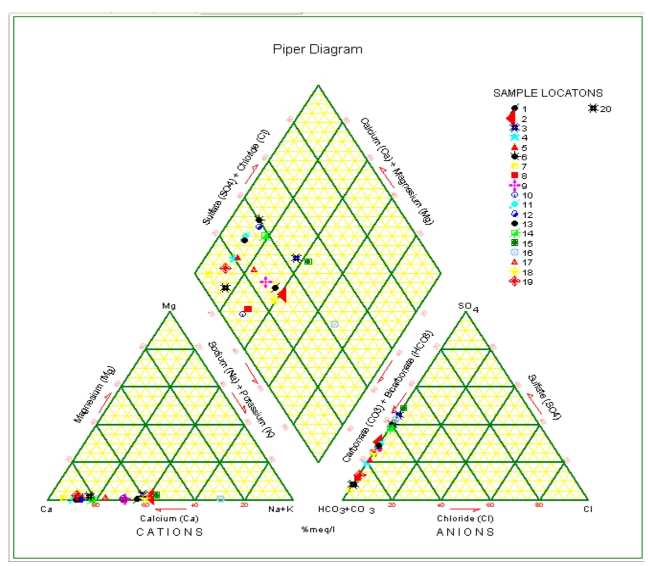

Figure 3: Piper diagram of groundwater in Kuje.

Table 2: Concentration of major cations and anions in milligram per litre (mg/l) of the study area.

Location	Carbonate	Bicarbonate	Nitrate	Nitrite	Chlorine	Chloride	Sodium	Potassium	Magnesium	Iron(III)	Copper	Calcium	Zinc	Sulphate	Fluoride
1	65	105	52	30	0.41	28	10	28	0.3	0.14	0.4	40	0.06	75	1.57
2	28	56	37	15	0.34	15	25	9.5	0.71	0.75	0.21	35	0.08	40	1.9
3	18	48	63	41	0.23	32	8	19.3	0.84	0.38	0.11	27	0.03	55	1.58
4	60	110	46	25	0.11	7	4	8.2	0.51	0.24	0.25	56	0.01	45	0.11
5	70	120	38	9	0.45	21	18	5.13	0.22	0.06	0.08	120	0.01	57	0.15
6	15	45	41	15	0.14	25	6	3.65	0.61	0.16	0.09	52	0.05	40	0.14
7	18	68	34	12	0.06	13	1.5	3.18	0.4	0.03	0.29	45	0.11	5	3.69
8	64	104	54	20	0.38	8	22	24	0.21	0.06	0.23	70	0.2	25	4.31
9	45	85	37	23	0.3	24	23	18	0.48	0.08	0.12	64	0.04	50	1.5
10	75	125	38	10	0.4	28	2.3	28.7	0.33	0.13	0.28	38	0.16	20	0.72
11	17	69	19	8	0.32	6	1.8	6.51	0.26	0.02	0.31	41	0.3	35	0.78
12	14	64	48	26	0.16	22	3.6	9.7	0.09	0.93	0.18	52	0.06	45	1.72
13	8	83	39	15	0.05	11	1.4	15.7	0.15	0.41	0.04	72	0.05	32	3.81
14	10	41	42	18	0.03	20	2.7	10.3	0.07	0.2	0.22	34	0.14	30	3.56
15	8	63	33	10	0.26	16	16	5.1	0.65	0.04	0.14	21	0.19	60	2.97
16	7	120	75	6	0.33	27	32	16.3	0.28	0.09	0.24	15	0.21	80	4.67
17	13	126	50	22	0.48	31	4.3	9.14	0.34	0.06	0.27	28	0.28	40	5.72
18	20	148	29	8	0.21	23	12	25.31	0.5	0.28	0.2	36	0.02	50	0.35
19	15	134	22	5	0.39	18	2.8	6.1	0.77	0.31	0.3	44	0.03	20	1.13
20	22	365	51	16	0.17	13	5.1	12.7	0.82	0.05	0.26	56	0.12	30	0.61

V. CONCLUSION

Water quality evaluation in the study area indicated that the pH, total dissolved solid (TDS), conductivity and the concentrations of Mg^{2+}, Na^{+}, Cu^{2+}, Ca^{2+}, Zn^{2+}, Fe^{2+}, NO_3^{-}, SO_4^{2-}, and Cl^{-} are within WHO (1996) standards for potable water. The Piper diagram indicated that the water is of $Ca{-}HCO_3$ type. Continuous monitoring of the ground water quality is necessary both from the Federal and State governments, private organizations and individuals because the quality of groundwater changes especially where there is continuous development. In addition, people should be encouraged to adopt simple water treatment practices before they make use of the water.

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